Performance of Tropical
Production and Processing
Systems Department (PERSYST)

Mission to the Institute of Tropical and Subtropical Cash-Crops (ITSCC) in Baoshan
Yunnan Academy of Agriculture Sciences (YAAS)
Yunnan, China

Evaluation of Coffee Production and Quality research activities

12 to 21 October 2009

Didier SNOECK, Agronomist
Gérard FOURNY, Technologist

CIRAD PERSYST Dept

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Content

Foreword

Acknowledgements

The consultants very sincerely thank Dr Liu Guanghua, Vice Director of the Institute of Tropical and Subtropical Cash-Crops (ITSCC) in Baoshan, who invited us.

Our special thanks also to the members of the Baoshan ITSCC coffee team for the warmness of their welcome and hospitality, and particularly to Miss Long Yaqin and Miss Zhang Xiaofang for their efforts as English-Chinese interpreters during the mission as well as for their friendship.

Our thanks also go to the plantation staff of the coffee bases for their welcome and friendly attitude at the plantation.

The consultants wish to thank Mr Li Litchi, International Cooperation Division project Officer who financed the mission and Prof. Tao Dayun, Director of the Yunnan Academy of Agriculture Sciences (YAAS) for their invitation to visit the coffee sector in Yunnan, and for their hospitality.

Abstract

This report covers a mission undertaken by the two CIRAD researchers in Yunnan, China from 12 to 21 October 2009. Its objective is to describe the current situation of coffee cultivation and research. Suggestions are made for improving coffee management and processing and for developing research programmes.

Keywords

China, Yunnan, coffee research, cultivation, processing, quality.

Background to the mission

Coffee growing was introduced at the end of the 19th century, but has only really developed since the 1990s. Coffee production rose from around 1,200 tonnes of green coffee in 1992 to over 33,000 tonnes in 2008. Yunnan supplies 97% of national production.

The purpose of the mission was to assess coffee agronomy and technology research activities at ITSCC (Institute of Tropical and Subtropical Cash-Crops), located in Baoshan county, Yunnan province. This mission had been preceded by an initial mission by D. Bieysse and P. Charmetant in February 2007 (i.e. in the middle of winter and just after the coffee harvest) concerning the genetic and phytopathological conditions of coffee growing.

The Chinese government is backing this initiative as it wishes to develop this province, which is still isolated and lagging behind due to its geographical remoteness from the central authorities. It considers that coffee growing could provide the driving force for development.

Yunnan does not have a true coffee research system, which is why YAAS requested CIRAD's support to take stock of the situation and propose research programmes suited to their needs in the fields of agronomy, ecology, plant pathology, entomology, post-harvest processing and quality. YAAS management also wants CIRAD's support for organizing their research projects, setting up the corresponding activities (field trials, etc.) and consolidating their farmer support programme.

Support for other crops (fruits among others) may also be considered.

ITSCC

The Institute of Tropical and Subtropical Cash-Crops (ITSCC) is one of the three institutes having coffee as the main crop in their development programmes. The other two institutes are based one in Jinghong, in Xishuangbanna county and the other in Ruili in Dehong county[1].

ITSCC is based in Lujiangba (valley of the River Nu), in Baoshan county. This institute is under the authority of the YAAS (Yunnan Academy of Agricultural Sciences), whose management is based in Kunming.

The institute employs 96 people, of which 30 coffee scientists and 30 for the other crops. Most of the researchers met are young and need training that is not available locally.

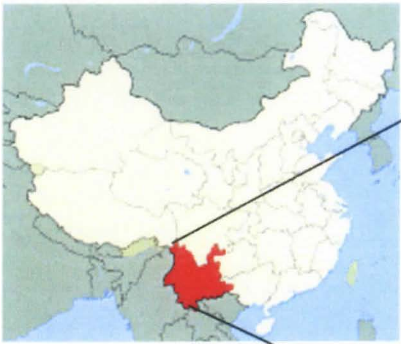
The centre has a collection of coffee trees, mango trees and lychee trees (etc.). Construction of a coffee post-harvest processing unit and an instant coffee production line is being considered.

The institute could use the seven coffee plantations (called "coffee bases") which it currently uses as demonstration points for recommended practices, from planting to post-harvest processing.

[1] A fertilizer trial was conducted at each of these two centres in 1993. The Ruili centre is geared towards varietal selection and one of their researchers (Mr Lu Cheng) is working on a thesis at Bonn University.

Coffee in Yunnan

Despite coffee first being introduced around 1900, followed by a second wave of planting material introductions in the 1950s, coffee growing is fairly recent. It has particularly developed since 1990.



In 1992, in Yunnan, there were around 1,700 hectares of coffee trees for a production of 1,200 tonnes of green coffee (cf. mission report by J. Snoeck).

The region is located at latitudes 21.5° to 26.0° North (latitudes of Cuba, central Mexico) and at elevations of 700 to 1,500 metres.

In 2008, more than 24,000 hectares were inventoried (of which 16,300 in production, and 4,100 planted during the year) for an annual production of 33,280 tonnes of green coffee.

Approximately 97% of Chinese coffee is produced in Yunnan. The remaining 3% are produced on the island of Hainan (primarily *C. robusta*).

Agronomy

Cultural practices and problems observed

Varieties used

In terms of genetic selection, around 250 acquisitions have been introduced by various sources: public partners (France, Laos, Vietnam) or private (Nestlé), but their dissemination has been very limited, for want of a breeding programme.

The plantations are composed of 77% dwarf type coffee trees (Catimor, especially CIFC 7963), and 13% coffee trees with a tall growth habit (6% Typica + 7% Bourbon). Farmers procure seeds from their neighbours or from their own plantations.

There are no seed gardens and virtually no organized programme for seed distribution and dissemination. A few large private groups supply ready-to-plant seedlings from centralized nurseries (in particular Hogu Coffee Co. Ltd. manages a 1/3 of production in Yunnan). But in this case too, the origin remains to be determined.

Density and pruning

The coffee trees are planted at very high densities: 2.0 m × 1.0 m (or even 2.0 m × 0.8 m). This practice arises from a trial using the Catimor coffee tree in the 1950s in the South (Jinghong), which concluded on the merits of a high planting density. It was fixed at 2 m × 1 m and is still in force. However, that density is recommended for both dwarf coffee trees and tall trees, but it may not necessarily be appropriate for this type of more voluminous coffee trees.

The coffee trees are usually grown in a multiple stem system with or without capping. Some suckers are sometimes tolerated. No rational pruning system seems to be adopted, particularly when the trees have suffered from overbearing die-back.

Shade and intercrops

The coffee trees are generally grown without shade, but:

- Young coffee trees are quite frequently seen to be intercropped with maize or grown under banana plants (photo 1), which are removed at around 3 or 4 years.
- A few cases of coffee plantations under teak or other shade (e.g. oak trees) were seen.
- In some plantations, we saw coffee trees intercropped with pepper.

It was seen, especially at high elevations, that coffee trees could suffer scorching due to the sun in summer (photo 2a) and cold damage in winter (photo 2b).

Weeding

Weeding is done with a hoe. In some plots it is done too deeply with the risk of cutting the roots of the coffee trees, thereby reducing their nutritional capacities and stability.

Adult coffee trees cover the soil and little weeding is required (photo 3b).

Fertilization

In terms of fertilization, farmers apply organic fertilizer (cow, pig, ewe manure, etc.) at a rate of 5 kg per coffee tree every other year. In the largest plantations, chemical fertilizer (15 N:15 P:15 K) is commonly used at a rate of 0.5 kg (in two applications/year).

Many of the coffee trees are suffering from overbearing die-back (photo 4). This type of damage results from a poor choice of fertilizer formulas and application rates (chemical or organic), which suggests that shade and lower planting densities should be used, along with appropriate fertilizer formulas.

Zinc mineral deficiency symptoms (photos 5a and 5b) were seen in plots of cut-back coffee trees. Excess phosphorus might be the cause, but the absence of soil analyses prevents the consultants from proposing a solution.

Insects

The incidence of insects is quite moderate. The following attacks are particularly found:

- Green scales, *Coccus viridis* (photo 6a) and black mildew (photo 6b), which develops on the secretions of this insect. The situation is quite severe and chemical treatments are sometimes applied.
- Stem and twig borers (photos 7a and 7b).
- Leaf miners (photo 8).

Diseases

The incidence of diseases seen during the field visits was relatively limited. The following damage was particularly noted:

→ <u>In the nursery:</u>

- Brown eye spot on young leaves in the nursery (photo 9).
- Damping off (photo 10).

This damage needs to be taken seriously, as it is usually due to poor upkeep practices (over-dense shade, excessive watering, soil that is too acid or too heavy).

→ <u>In the field:</u>

- Leaf brown eye spot (photo 11) and berry blotch (photo 12). This disease, caused by *Cercospora coffeicola,* is known to be linked to strong sunlight and inadequate mineral nutrition.
- Leaf diseases (photo 13) and coffee berry diseases (photo 14). The symptoms are not typical and the consultants cannot specify the name of the fungus or fungi responsible (*Colletotricum* or *Cercospora* or *Fusarium*, etc.). Only identification by isolation would determine the fungus responsible for the damage. However, the levels of attack seen seem low and a relation with poorly regulated fertilization or excessive sunlight has to be considered.
- Leaf rust at low elevations (photo 15a). Some farmers complained about the Catimor variety distributed and mentioned a drop in leaf rust tolerance, but that phenomenon cannot be confirmed as there is a total absence of any surveys. The incidence observed is not alarming and the increase in attacks with age may be due to poor fertilization. However, the damage seen in February 2007 (after the harvest) in a Bourbon plantation was very severe (photo 15b).

Recommendations

The problems arise from the fact that just one recommendation is sent out irrespective of the type of planting material, or ecological environment: one variety (at 77%), an identical planting density for two types of trees of different sizes, a single chemical and organic fertilizer formula, irrespective of soil and climate.

This single recommendation is obviously not suitable everywhere and may explain the abovementioned problems. A research system needs to be established to adapt recommendations to diverse growing conditions.

We also found a total lack of knowledge about the degree of the problems (quantity, duration) observed in the field and about the questions that farmers might have for research. Yet it is very important for research to work together with producers to anticipate requirements and propose solutions as soon as the need occurs, at all levels of the supply chain.

In order to address all these issues, we feel it is important for YAAS to structure its institute by adding a research service and programmes adapted to their needs in the fields of agronomy, ecology, plant pathology, entomology, post-harvest processing and quality.

Surveys need to be conducted to provide basic knowledge and determine farmers' needs.

Field trials need to be set up so that researchers can propose various solutions adapted to diverse contexts/environments to farmer supervisory bodies.

Support in setting up development projects needs to be envisaged. To that end, we suggest that the director of the institute, possibly accompanied by researchers from different specialities, visit CIRAD in Montpellier (tour of laboratories working on breeding, technology (and cupping), diseases/insects, farmer support, etc.), and to a research centre focusing on arabica coffee preferably in a modestly sized producing country (Nicaragua, Burundi?). Thereafter, collaboration could be envisaged between our two organizations for:

- the creation of such a structure,
- researcher training,
- drawing up research projects for submission to funding agencies,
- farmer support (collective training, coffee growing manual).

Varieties used

We propose to:

- screen the varieties already introduced.
- set up seed gardens to ensure the good quality of distributed seeds.
- set up a breeding programme to prepare for future needs.

Density and pruning

The tall type coffee trees (Typica, Bourbon, Java, …) should be planted at a lower density than dwarf trees (e.g. 2.5 m × 2 m). Pruning should be on three stems with free growth and periodic cutting back.

If plants have suffered from overbearing die-back, they must be regenerated (cut down to 25 cm from the ground) leaving two or three branches to promote recovery.

We suggest setting up a multi-site pruning and density trial (at different elevations and latitudes) to define the best options for the different types of coffee trees depending on local conditions (soil, climate).

Weeding

Weeding is done with a hoe. It is essential not do dig too deeply otherwise the roots of the coffee trees will be cut, thereby reducing their nutritional capacities and their stability.

Shade and intercrops

Slight shade over the coffee trees provides a good balance between nutrient uptake and carbohydrate production by the photosynthesis system. Using legume plants able to fix atmospheric nitrogen via rhizobia reduces competition for nitrogen.

In high elevation regions, the use of shade trees is recommended to reduce seasonal problems (alternating hot in summer – cold in winter). The choice of trees also depends on the utility of the species: commercial, fruit production (citrus, macadamia), spices (nutmeg), etc.

We suggest setting up some trials comparing shade tree species and coffee planting densities (tall and dwarf trees) in different ecological situations to propose the best options.

Fertilizer formulas will have to be adapted to the amount of shade used.

Fertilization

Fertilizer formulas and application rates must be adapted to the context. Indeed, the quantities of nutrients to be provided depend on the quantities already present in the soil and the quantities exported by harvested products (and therefore the varieties used).

The quantities of each of the chemical elements contained in the various types of manure applied need to be analysed to take into account the quantities of each element provided by organic fertilization.

N : Even without these analyses, it can be seen that the quantities of nitrogen provided by chemical fertilizers are excessive when compared to the other nutrients, due to regular applications of large amounts of manure. Excess nitrogen does not increase yields, on the contrary it acidifies the soil and leaches cations more rapidly. Nitrogen must be applied at the beginning of the wet season and two months before the harvest.

P : The results of trials conducted in southern Yunnan concluded that phosphorus is not necessary, yet the quantities applied are considerable. But excess P blocks zinc. Phosphorus must be applied at the beginning of the wet season.

K : K-N antagonism must be taken into account when choosing formulas. In well-saturated soils, the amount of K in the fertilizer formula must be equal to half the N. Potassium must be applied at the beginning of the wet season and four months after, to sustain fruit ripening.

Some fertilizer trials need to be conducted to define the needs of immature plantations and of productive mature plantations. The trials will have to be replicated:

- on poor soils, where all the nutrients will have to be tested,
- on rich soils where only nitrogen rates will have to be tested.

To help the researcher decide which formulas should be compared, we recommend using the "Soil Diagnosis" tool developed by CIRAD.

Insects

For the time being, there is not enough hindsight and information about the degree of attacks. A survey needs to be conducted to identify problems and their severity.

Diseases

The attacks seen at the beginning of the harvest did not seem to be very severe. It can therefore be imagined, in theory, that these are secondary phenomena linked to a nutritional deficiency.

However, given the damage seen at the end of the harvest and cold period (winter), and the lack of hindsight and monitoring, we are unable to assert that hypothesis. A survey will have to be conducted to identify problems and their severity.

Technology

Field visits and problems seen

The mission took place at the start of the harvest in the Yunnan zone. The harvest was under way in the lowest zones and it was possible to view post-harvest processing in two large and two small plantations.

1 – Post-harvest processing in the small plantations

The farms were equipped with a small pulping centre equipped with a drum pulper (inexpensive local construction) and an electric motor, with a tank for fermentation (Photo 16). Drying was carried out on cemented areas.

Photo 16 – Pulping centre in a small plantation

Fermentation was carried out in water, varying in duration depending on the outside temperature [2] (between 8 hours and 2 days). The water used was from the mains supply so was of very good quality. After fermentation, the coffee was dried directly on the ground.

The coffee pulps were generally spread in the plantations under coffee trees or banana plants, without prior composting (Photo 17).

[2] The Yunnan coffee zone is located at approximately 25° latitude North and is therefore under the influence of the boreal winter.

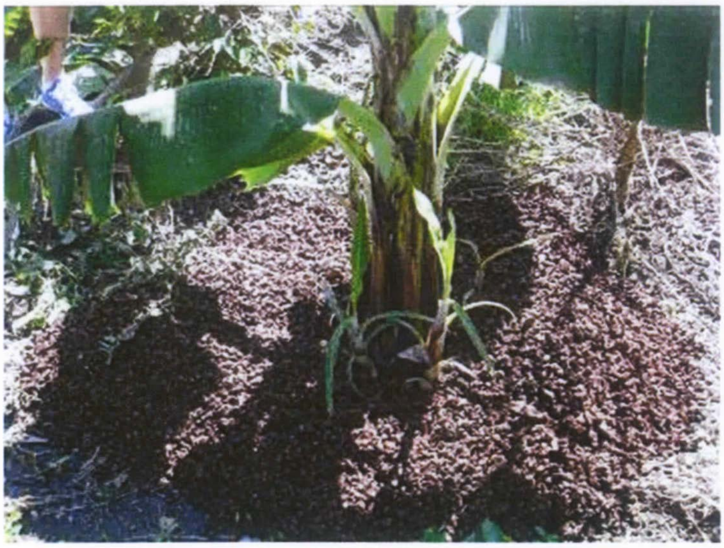


Photo 17 – Coffee pulps under a banana plant

2 – Post-harvest processing in the LARGE plantations

Three visits were made to the post-harvest processing centres of large plantations; two of those centres were operating at the time of the visit.

The pulping equipment in the processing centres came from South America (Brazil and Colombia). Pulping was carried out with vertical drum pulpers (Penagos, Pinhalense). In the Yun Da 120 plantation, pulping used to be followed by mechanical mucilage removal, but the process was halted as coffee buyers preferred soaked coffee to coffee from which the mucilage had been removed (quality problem).

Post-harvest processing was limited to fermentation in water (duration varying depending on the outside temperature – 1 to 2 days); there was no coffee grading. After fermentation, the coffee was dried on the ground (concreted drying areas).

Waste water was discharged into the wild, pulps were packed into a pit in which composting was not effective (problem with leaching by rainwater and pulping water).

3 – Main problems identified during the visits

3.1 – Small farms

The following photos (Photo 18) illustrate the lack of care taken with post-harvest processing:

- Poor quality harvest (photos 18.1 and 18.3)
- Dirty pulper (photo 18.2)
- Dirty work place (photo 18.4)

Photo 18 – Quality problems on small farms

The pulping units were well adapted to preparing fully washed coffee but the lack of care taken with machine cleaning suggested that greatly fluctuating qualities were achieved (quality problem: stinkers and other technological defects – health problem: existence of OTA).

3.2 – Large plantations

What was found in the processing centres of the large plantations visited was somewhat the same, as illustrated in the following photo (Photo 19):

- Poor quality harvest (photo 19.1)
- Dirty unripe/ripe separator (photo 19.2)
- Pulp pit (photo 19.4)
- Cherries left in the unloading hopper (photo 19.4)

Photo 19 – Quality problems in the large plantations

Recommendations relative to the observations made

1 – Recycling of pulping water

At this latitude (approximately 25° North) fermentation takes a long time in winter (identical problem in the northern Mexico production zone). Recycling pulping water in large plantations would help to reduce the quantities of water used and speed up fermentation (existence of endogenous enzymes in pulping water).

This operation calls for pulping water collection in a cemented tank and a pump to return the water to the pulper (Photo 20). This arrangement is routinely used without any problems in countries carrying out post-harvest processing to produce fully washed coffees.

Photo 20 – Waste water recycling system

2 – Utilizing pulp

Coffee pulps can be composted through their digestion by earthworms. Some precautions have to be taken to carry out this very simple operation.

In order to compost coffee pulps they have to be stored in a place protected from leaching by rainwater and pulping water. They should therefore not be stored in a pit where rainwater tends to stagnate.

The following system enables easy composting (Figure 1):

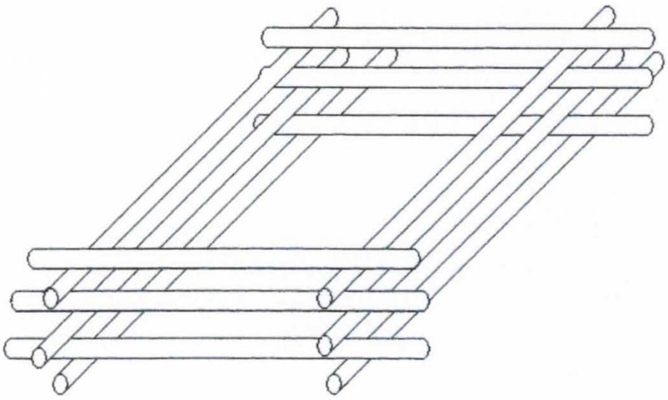


Figure 1 – Bamboo composter for pulp composting

These composters can measure 2 m × 1 m, for example. They are constructed by stacking bamboo poles on each other to a height of around 0.80 m. Pulps are stored in the composters as and when they are produced. The composters are constructed directly on the ground in contact with the soil (not on cement, to enable earthworm access). They are covered with a polyethylene tarpaulin to protect them and their contents from rainwater.

After fermentation (destruction of the organic matter), all the pulps are digested by earthworms. This method provides a compost rich in organic matter which can easily be mixed with heavier soil for use in nurseries.

3 – Quality improvement

This action is complementary to the proposal made for the research/development programme that will have to be implemented (cf. following section).

As part of its coffee producer assistance programme, ITSCC should draft a good procedures manual in order to make stakeholders in the coffee supply chain aware of the quality problems. This manual can be distributed during professional meetings, via middlemen, or in information meetings, etc.

The content of the manual would be geared towards good agricultural practices for coffee growing in general, i.e. as much about agronomy as crop protection and post-harvest processing.

Drawing up a research and development programme

There will be different kinds of impacts:

- *Socio-economic*: contribution to developing economically viable and stable farming systems,
- *Environmental*: preservation of areas by developing crop management sequences for replanting/regeneration, promotion of simple or agroforestry farming systems, and integrated cropping system protection,
- *Scientific and technical*: creation of a regional network of technicians and researchers, training in systemic approach methods and participatory research, making use of the knowledge and know-how of all stakeholders.

a/- Plant technology, agroforestry techniques and crop diversification

- Study on the vegetative status of coffee plantations and their management by farmers, with the factors for success or failure: coffee tree pruning, changes in planting density, notably depending on the origin of the planting material, soil quality, type of shade, types of permanent shade acceptable to farmers, management of that shade, etc.

b/- Breeding

- Identification of hardy genotypes enabling rapid installation of the plantation, possibly adapted to permanent shade, more tolerant of climatic adversities (drier climate) and cultivation contingencies (parasite pressure, temporary "abandoning" of the plot, etc.).
- Evaluation of the adaptation of selected varieties to estate or smallholder growing conditions.

c/- Physiology and nutrition

- Characterization of soils and their fertility.
- Maintenance and restoration of soil fertility through fertilizer formulas, either chemical or not, adapted to growing conditions, especially in borderline zones (high elevation or latitude) and in mature plantations.

d/- Crop protection

- Characterization of parasite pressure – pests, diseases, weeds – and of its effects on yields, not only of coffee trees but also of other crops on the farm, efficiency of local weed control methods.
- Development of techniques to control weeds in coffee plantations and in food crops.
- Development of IPM methods against sucking insects and coffee tree fungal diseases, reducing the need for chemical control.

e/- Economic and social sciences

- Identification of factors determining producer strategies.
- Characterization of the technical, economic and social environment of the planter, and ensuing strategies.

- Definition of the conditions for adopting innovations and development of decision-support tools based on work focusing particularly on:
  - the availability of inputs, the level of their use on the farm and their impact on incomes,
  - the availability of credit,
  - competitiveness between crops on a farm (place of coffee),
  - market access opportunities, coffee marketing circuits,
  - levels of farmer organization, cooperatives and producer organizations.

f/- Post-harvest technology

The purpose of this programme is to study the **influence of post-harvest processing on coffee quality** and to study a **reduction in the organic matter contained in waste water** from coffee processing, whilst maintaining the specific quality of wet processed arabica coffees.

Based on the existing equipment for coffee mucilage removal (Penagos, Pinhalense), some trials will be necessary to compare the quality of a coffee obtained by fermentation and coffee obtained by mechanical mucilage removal.

Based on the results obtained, partial mucilage removal[3] will be tested (possible development of a machine for this work), in order to obtain coffees of comparable quality to that of coffees obtained by fermentation. The organic matter load will be measured by quantifying BOD and COD, in order to determine the best compromise between coffee quality and environmental pollution.

The programme will involve the installation of an experimental centre for coffee processing at one of the coffee bases where ITSCC operates.

The parameters adopted for assessing coffee quality will be:

- Chemical composition
- Near infrared spectra (NIRS)
- Green coffee colour
- Sensory tests
- OTA contents

g/- Quality of coffees produced in Yunnan province:

The purpose of this study, which will be based on a survey in Yunnan province, is to determine the main defects encountered in the processing centres.

Based on an inventory of the coffee processing centres (small and large farms), a survey involving sampling will be conducted in Yunnan province. After assessing the sampled coffees, the samples will be cupped by a panel of tasters trained beforehand at the CIRAD sensory analysis laboratory in Montpellier.

Some of the samples will be analysed to determine the OTA content of green coffees.

[3] Equipment currently on the market carries out total mucilage removal

The results of the survey will be used to draw up a good practices manual principally focusing on post-harvest processing.

h/- Backing for support laboratories

The laboratory work (soil analyses, identification of insects and parasitoids, fungal or viral diseases, physico-chemical and sensory analyses of coffees) that will be necessary to support action-research work will preferably be done by laboratories in the zone in question. Failing that, the CIRAD laboratories can be called upon.

i/- Installation of a sensory analysis laboratory at ITSCC

The purpose of this programme is to set up a sensory analysis laboratory at ITSCC. A training programme will be drawn up in conjunction with the Montpellier laboratory.

Training will concern coffee and also the tropical fruits involved in one of the Institute's programmes.

Conclusions

Dr. Didier SNOECK and Dr. Gerard FOURNY from CIRAD were invited to assess agronomy and technology research activities at YAAS ITSCC from 12 to 22 October 2009.

At the end of the mission, a meeting was organized to discuss the possibilities of cooperation between the two organizations and the following opinions were put forward:

1. The ongoing development of coffee in China, especially in Yunnan, is very promising and requires more research support.
2. CIRAD and ITSCC would like to cooperate on coffee research including coffee breeding, cultivation, and quality improvement.
3. CIRAD and ITSCC would like to act together for the related fields of coffee research to promote cooperation.
4. CIRAD could provide assistance to ITSCC in the organization of their research projects to improve coffee research levels and ability. Particularly to:
    a. Conduct surveys to identify the main problems of the coffee supply chain on different levels
    b. Structure their research programmes to anticipate demand and propose solutions to the problems in the coffee supply chain
    c. Organize training programmes to assist researchers in setting up trials (agronomy, technology, quality, etc.).
5. CIRAD could provide assistance to ITSCC to improve their development activities (i.e. access to seeds, organise training sessions for farmers and draft a technical manual).

To achieve this goal, we suggest that ITSCC managers (and scientists) should visit:

- CIRAD to gain an overview of a possible partnership;
- Another research institute in a producing country having the same targets (e.g. Nicaragua, or Burundi).

Annex 1: Schedule and coffee farms visited

Schedule

12 – 13 October: Montpellier – Kunming: by air
Kunming – Baoshan – Lujiangba by car
Night at ITSCC

14 – 18 October: visit to the coffee bases, factories and ITSCC centre (in Lujiangba)

- 14 Oct. San Li coffee (near Nujiang city). (25.8075 N, 98.8436 E)
  Since 1998, size: 200 ha.
  Altitude 1000 – 1450 m; Temp.: 23°C, Rainfall: 1100 mm
  Manager: Mr Ou BoYi

- 15 Oct. Lv Shi coffee base (25.2294 N, 98.8142 E)
  Since 1999, size: 166 ha
  Altitude 1350 – 1580 m; Temp.: 19°C, Rainfall: 1100 mm (no frost in winter)
  Observations: Scales, die-back

  Xin Zhai (25.0184 N, 98.8247 E)
  Since 1982, size: 600 ha
  Altitude 1100 – 1450 m; Temp.: 23°C, Rainfall: 1100 mm
  Manager: Mr Nan Xian Wen

  Yun Da 120 Coffee (24.8608 N, 98.8947 E); since 1998, size: 153 ha
  Altitude 700 – 850 m; Temp.: 21°C, Rainfall: 760 mm
  Manager: Mr Xu
  Observations: Ecocert 2003-2005, Pinhalense pulper

- 16 Oct. Hogu Coffee Co. Ltd. & factory (Dehong county) and coffee area
  Met people from Ruili Tropical Crops Research Institute
  Visit to Hogu coffee farm (24.3692 N; 98.4325 E), altitude: 800 m

- 17 Oct. ITSCC field, factories, and germplasm garden (24.974 N, 98.8776 E)

- 18 Oct. Meeting at the Institute.
  Departure to Baoshan by car.
- 19 – 20 October Travel to Kunming (through Dali) by car.
  Report to YAAS Directors and discussions.
- 21 October: Departure for France

A few data

Area measurement unit: 1 mu = 667 m² (= 1/15 of a hectare)

Purchase price paid to producers for green coffee: 12 to 20 yuan (€ 1.2 to 2.0) depending on the regions.

Annex 2: Persons met

Yunnan Academy of Agricultural Sciences (YAAS), based in Kunming, Yunnan Province
Pr. Tao Da Yun, Director General
M. Li Lichi, International Cooperation Division

Institute of Tropical and Subtropical Cash Crops (ISCCT,);
YAAS in Lujiangba, Baoshan Prefecture, Yunnan Province
M. Huang jia xiong, Director, Vice-Professor
M. Liu Guang-hua, Vice-Director, Associate Professor
Ms Zhang Xiaofang: Ecologist
Ms Long Yaqin: Pest & diseases
Mr Yang Shigui: Agronomist
Mr Huang Jian: Agronomist
Mr Wen Zhi Hua: Coffee processing
Mrs Lv Yu Ian: Plant nutritionist

Annex 3: Photos taken on the farms visited

1. Coffee intercropped with: a. Banana b. Shade trees		
2. Effect of climate a. Sun burn (summer period) b. Cold symptoms (winter period)		
3. Insufficient weeding in young stages, but weed incidence is reduced in adult coffee plots		
4. Overbearing die-back		
5. Zinc deficiency a. Fish-bone distorted young leaves b. Chlorosis on older leaves		

6. Green scale a. Insects b. Black mildew	 
7. Borers a. Stem	 
b. Twig	
8. Leaf miner	
9. Brown eye spot	
10. Damping off	

11. Leaf Cercospora (brown eye spot on adult coffee tree)	
12. Berry blotch	
13. Leaf disease (anthracnose)	
14. Coffee berry diseases	
15. Leaf rust a. Fungus on coffee leaf b. Damage seen after harvest on Bourbon	 

Annex 4: Fertilization research programme

Objective:

To assess fertilizer use in relation to soil, climate, variety, and yields levels.

Justification:

There is no research on soil science related to coffee fertilizer requirement.

Trials are necessary to determine economical application rates for nitrogen fertilizers on the different soil types in the region, and also to test the best adapted nutrients levels as recommended from the soil diagnosis method. It is recommended to check the method for the particular ecological conditions of South Yunnan: types of soils, rainfall distribution and alternation of low and high temperatures, cool and warm season, due to the latitude.

Soils are generally derived from granitic materials giving red clay-loam, with a pH around 6.5. Old research trials on fertilizers in 1950 showed a response to nitrogen and to potassium. Researchers found that phosphorus fertilizer is not necessary.

The lack of complete and reliable soil analyses makes it impossible for the consultant to give proper fertilizer recommendations. Therefore, trials are necessary to determine optimum economical rates for the various nutrients.

As yet, no correlation has been established between soil or leaf analyses and levels of nitrogen fertilizer requirements. In order to give a complete recommendation:
Soil analyses should be used to:

a) calculate the need for liming,
b) identify possible unfavourable physical soil properties (excessive density, dense horizons) which could restrict growth and yield,
c) make fertilizer recommendations: define fertilizer formulas

Leaf analyses should be used to:

a) evaluate the nutritional status and the probability of having a response to fertilizers,
b) verify the balance in the nutrition of the coffee trees and, hence, in the natural fertility of the soil or in the fertilization,
c) assess the possibility of toxicity of some elements,
d) accompany, evaluate and adjust the fertilization programme for the year and in the long run.

Methods:

Establishment of field fertilizer trials, calculations and recommendations.

Laboratory analyses required

Soil texture (% clay, silt and sand),
C, N, avail P, K, Ca, Mg, Cation Exchange Capacity and in certain cases exchangeable Al (when soil pH and exchangeable bases are low), pH H_2O.

Fertilizer application method

- No tillage, no deep hoeing of the soil, no ditches. Coffee feeder roots are located in the top horizon, rich in organic matter. Estimations are that 70 to 80% of feeder roots are in the top 20 cm of the soil. Avoid deep ploughing or deep hoeing which destroy the feeder roots and decrease uptake of fertilizers and nutrients by the coffee trees.
- Weed plantation before applying fertilizers, by light surface hoeing not deeper than 1 cm.
- Apply organic manure at the beginning of the dry season (after harvest).
- Fertilizers should be applied under the canopy of the coffee leaves.
- Formulas should be determined on the basis of multi-site trials for nitrogen and of soil analyses for P, K, Ca, Mg. Micronutrient requirements are determined by leaf analyses.

Standard protocol for fertilizer trial

Preliminary

Select a good location
Record field history and preceding crops

Field preparation and planting

- Stake at 2 m x 0.75 m (6666 Catimor/ha - 444/mu),
- Hole at 60 x 60 x 60 cm, or dig ditches 60 cm wide and 60 cm deep,
- Refill the holes or ditches, the day after holing with surface soil adding organic manure (5 kg/stake), Rearrange the stakes,
- Number the plots with metal boards,
- Plant the Catimor coffee and cover with temporary shade (palm fronds or branches).

Working calendar

Month – 9 (Sept - October): Sow seed in germinating bed, covered with a plastic sheet to keep it warm.
Month – 5 (January): Prick out seedlings in polybags. Put polybags under plastic tunnels during cold season to promote growth of plantlets.
Month – 4 (February): Field delimitation and clearing. Soil sampling.
Month – 2 (April): Field preparation: pegging, holing, organic manure, immediate refilling, rearranging stakes.
Month – 1 (May): Prepare trial plan and arrangement in the field.
Month – 0 (June): General weeding. Plant trial. First fertilizer application according to protocol (different treatments).

Pruning is done on one free growing stem, no capping, regular removal of suckers and stumping after 5 or 6 harvests, depending on tree growth and development.

Samples of experimental designs

Determination of treatments:

The soil diagnosis method should be used to define the treatments. As a general rule, recommendations could be:

- On well saturated soils (Sat.> 40 %), one can expect positive responses to nitrogen alone. Trials will compare N rates to get a response curve and to be able to make an economic study. On older coffee, the soil diagnosis method should be used to determine the fertilizer treatments.
- On soils with low exchange capacity (< 5 m.e. %) or on leached soils (Sat < 40 %), trials with complete formulas must be laid out, with factorial combinations of N, P, K, Ca, Mg.

Case 1: Well saturated soils

Treatments:	Control	T2	T3	T4	T5	T6
kg/ha N	0	69	138	207	276	345
kg/ha urea 0	150	300	450	600	750	
kg/mu urea	0	10	20	30	40	50
g/tree urea 0	22.5	45.0	67.5	90.0	112.5	

Layout: 6 treatments x 12 replicates = 72 unit plots.

This gives the possibility of transforming the layout of the trial to make factorial studies of N with K, Ca, Mg, during the following cycles.

Case 2: Leached soil

Treatments:					
N :	2 effective levels:	1 -	2 :		140 and 280 kg/ha N;
K :	3 effective levels:	1 -	2 -	3	kg/ha K2.0;
Ca :	2 effective levels:	1 -	2		kg/ha CaO;
Mg :	3 effective levels:	1 -	2 -	3	kg/ha MgO.

Rates of 1, 2, and 3 are computed according to the soil analysis. If necessary, P can also be studied. 72 plots =2 replicates of 36 factorial combinations.

Field layout: - Unit plots: 4 rows of 6 trees spaced at 2 m x 0.75 m = 8 m 2 x 4.50 m = 36 m².
- 1 border row at each end of the plots,
- No lateral border rows.

Date of applications

	May	July	September
Nitrogen	x	x	x
Phosphorus	x		
K and Mg	x	x	
Calcium	in February-March (dry season)		
Organic manure	in January-February (dry season)		

Observations

- Susceptibility to pests and diseases, die-back.
- Growth and development.
- Harvest per plot and weight in kilograms of fresh cherries.
- Bean size and cup quality.

Soil sampling should be done every 2 years per elementary plot (6 borings per plot in the fertilized area).

Annex 5: Soil Sampling

Recommendations for taking soil samples

Soil evaluations can only be as accurate as the samples on which they are made. The proper taking of soil samples is, therefore, absolutely essential. Unless the samples are as representative as possible of the soils being tested, fertilizer recommendations based on their analysis will not be accurate and may be misleading. The same care and detailed attention must be given by the farmer to taking the samples as is given by the chemist analysing it.

Principles of sampling

To be thoroughly representative, each soil sent to the laboratory must be a composite sample, that is, it must comprise many sub-samples taken from different parts of the area for which recommendations are required.

Each composite sample should contain at least 30 sub-samples, even on small fields, taken at random all over to be evaluated field. In the case of cocoa or coffee plantations, the 30 sub-samples should be taken at 30 cm from the stems under 30 different trees.

In the case of big plantations, (more than 10 hectares) it will be necessary to take several composite samples (one per block or per plantation) according to the following criteria:

- type of soil (changes in colour, in texture or in slopes)
- aspect of natural or cultivated vegetation (forest – savannah - fallow - crops)
- cultural history of the plantation (management – fertilizers - shade). In a fertilizer trial remove all fertilizer residues prior to sampling.

Minor variations of soil must be ignored and abnormalities must be avoided, e.g. the vicinity of ant heaps, ant bore-holes, contour-ridges, drains, gravelly patches and sites for stacking fertilizers, composts or crop residues.

Sampling method

1. Leaf litter is brushed aside without disturbing the superficial humus-rich top layer.
2. If an auger is available, cores are taken to a depth of 20 cm and put in a clean bucket which has never carried fertilizers or chemicals. If no auger is available, a 30 cm deep hole is dug with a spade. On one of the vertical faces, a thin 1 cm thick slice of earth is cut uniformly to a depth of 20 cm. Care must be taken to collect the whole of the slice of soil, including

the surface soil. The sub-sample is put in a clean bucket. 30 sub-samples are gathered to make one composite.

3. When all the sub-samples from the sampling area have been placed in the container, they are thoroughly mixed on a very clean canvas or plastic sheet. Then the soil is sieved on a sieve with square 4 to 5 mm mesh. After homogenization, about 1 kg of soil is taken and put in a clean plastic bag with a waterproof label.
4. Soil samples are then air dried on a newspaper or any strong paper. When dry, put 500 grams of soil in a clean strong plastic bag with a waterproof label and send to the laboratory. The remaining soil of the composite sample is kept at the farm, in case of loss during transfer.
5. In the field, complete the form as fully as possible. This form must accompany the samples.
6. Send samples and forms to the laboratory.

Minimum size of soil samples

- 300 g rough soil for traditional analysis of the basic elements,
- 400 g rough soil (300 g dried soil sieved to 2 mm) for traditional analysis + trace elements,

Soil analytical methods

Soil texture (% clay, silt and sand)

pH H_2O and pH KCl (1: 1),

total C (digestion with chromic acid and spectrophotometric analyses (Heanes, 1984)

total N (Kjeldahl method),

Available P by the Olsen-Dabin method or the Truog method.

Exchangeable cations (K, Ca, Mg) and CEC by the ammonium acetate method (at pH 7).

Optional: Zn, B, by EDTPA methods